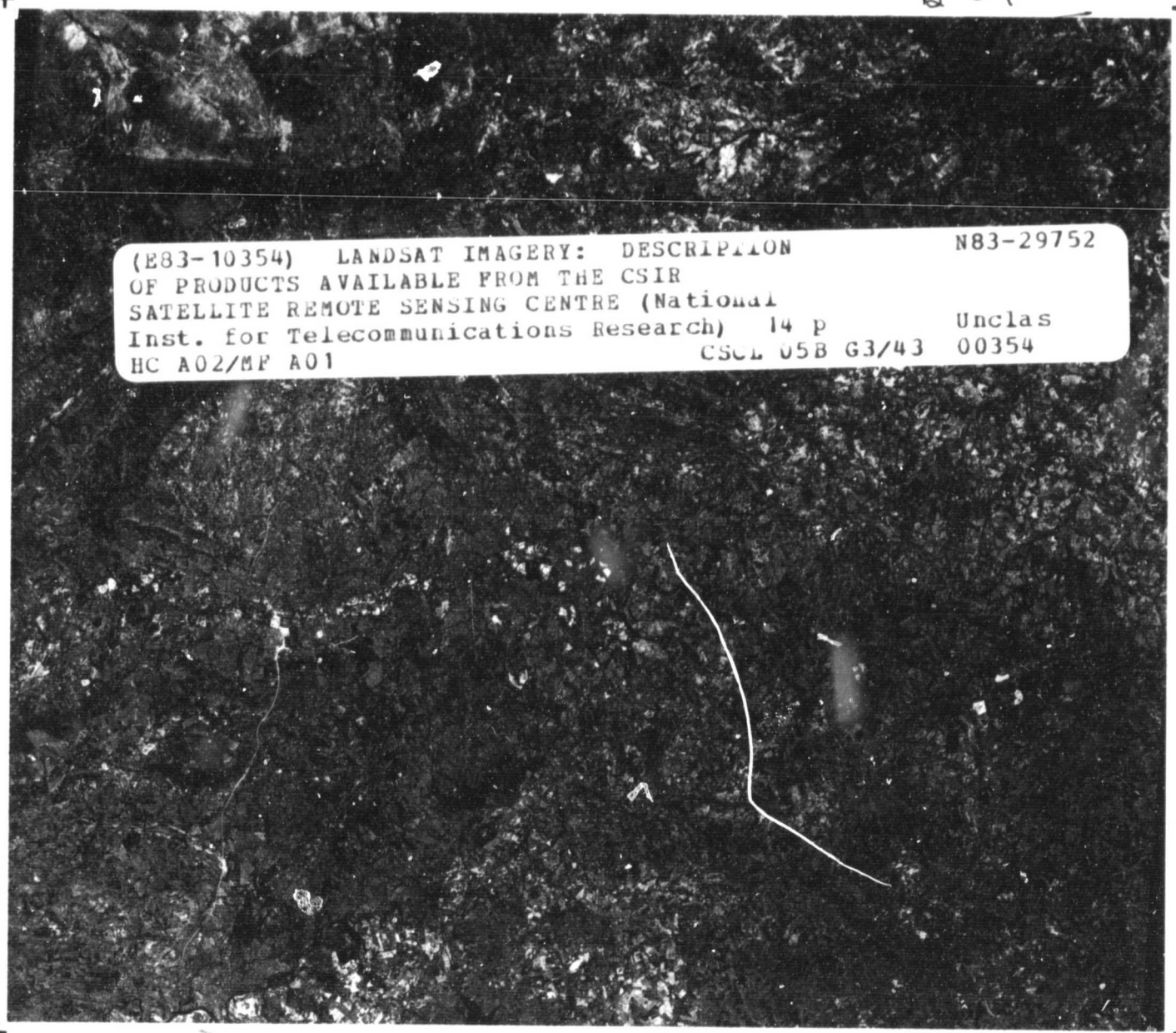
Landsat Imagery

Description of products available from the CSIR Satellite Remote Sensing Centre



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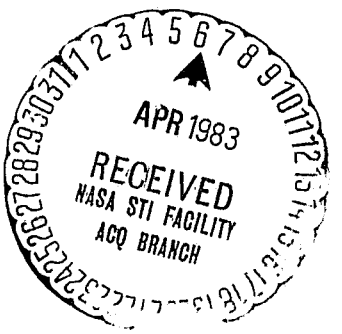


CONTENTS

INTRODUCTION

This brochure contains key information about Landsat image products and services available from the Satellite Remote Sensing Centre (SRSC), which is operated by the National Institute for Telecommunications Research of the CSIR. It provides prospective users with details on how to establish whether imagery for their area of interest is available and how to obtain the images that they require.

The facilities at the Satellite Remote Sensing Centre were set up by the Council for Scientific and Industrial Research to enable it to receive Multispectral Scanner (MSS) imagery from the United States Landsat series of satellites. In accordance with an agreement between the National Aeronautics and Space Administration (NASA) and the CSIR, this imagery is available to all users on a non-discriminatory basis, at prices similar to those of the EROS DATA CENTER in Sioux Falls, South Dakota, USA.

Landsat imagery has already proved its value to important sectors, notably those concerned with mineral exploration and to an increasing extent in agriculture, forestry and other applications relating to renewable resources. It is hoped that this document will facilitate procedures for users who are interested in identifying and acquiring Landsat imagery for research or applications. For more detailed information on the Landsat system and remote sensing as a support technique, the reader should consult the considerable technical literature available.

THE LANDSAT SYSTEM

The first Earth Resources Technology Satellite, ERTS-1 (later renamed Landsat-1), was launched by the United States National Aeronautics and Space Administration (NASA) during 1972. Landsat-2 and Landsat-3 succeeded the first satellite in 1975 and 1978 respectively. These satellites have a near polar circular orbit at an altitude of approximately 920 km. They circle the earth in 103 minutes, thus completing very close to 14 orbits a day. The Landsat sensors are designed to acquire imagery along approximately north-south strips with a swath (width) of 185 km. A total of 251 such successive orbits allow coverage of almost the entire globe, excluding only the polar areas. The system and orbit configurations combine to allow the satellite, weather permitting, to 'view' a given area of the earth's surface every 18 days. Figure 1 shows the typical daily ground trace of Landsat during one day. Figure 2 is a schematic illustration of a number of ground tracks over Southern Africa.

A further feature of the orbits is that they are sun-synchronous, which means that Landsat passes over the same point on the earth at the same local sun time every 18 days (around 09h20 for Southern Africa). As a result, the sun angle will remain nearly the same for several weeks. However, as the seasons change, so will solar elevation angles and the resulting illumination and lighting conditions. Solar elevation for Landsat 1, 2 and 3 is shown as a function of latitude and month in Figure 3.

Multispectral Scanner (MSS)

Radiation reflected from the surface of earth is received by the Multispectral Scanner on Landsat in four spectral bands. A scan mirror oscillating perpendicular to the ground track of the satellite is used to reflect the radiation to a detector system through a number of fibre optic bundles, and the radiance values are then converted to digital format suitable for tape recorder storage on the spacecraft or transmission to a suitably located and equipped ground station. Thus system design allows the forward

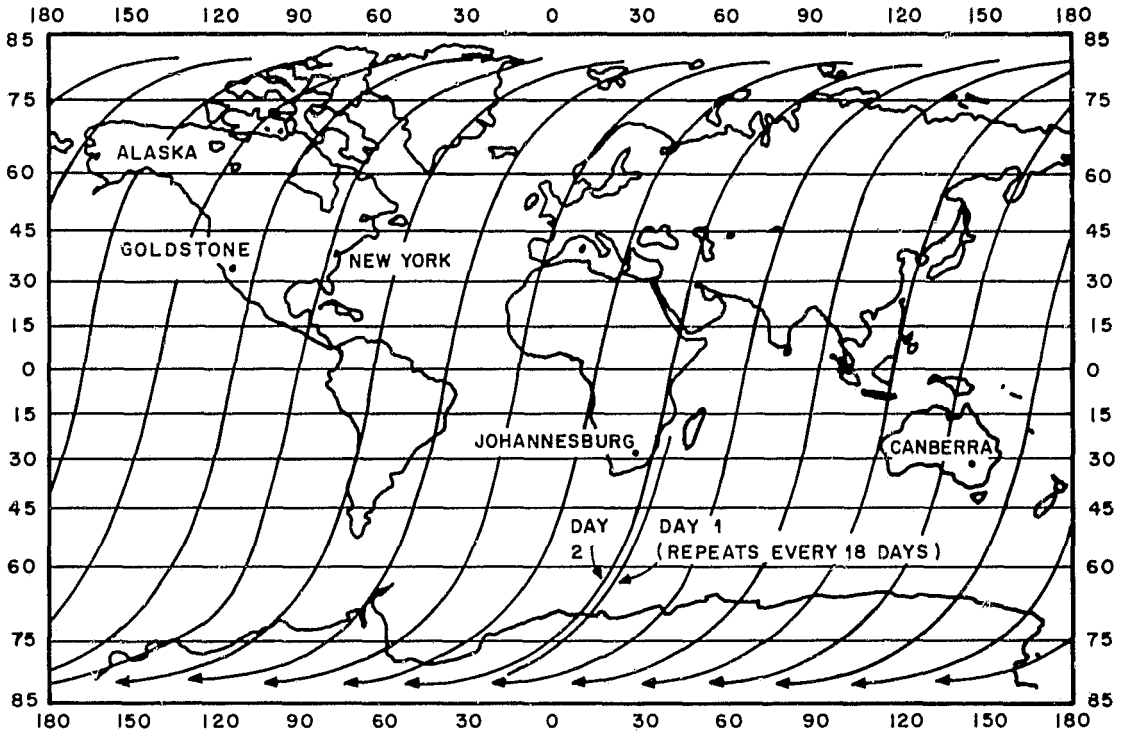


Figure 1: Typical daily ground trace of Landsat for one day.

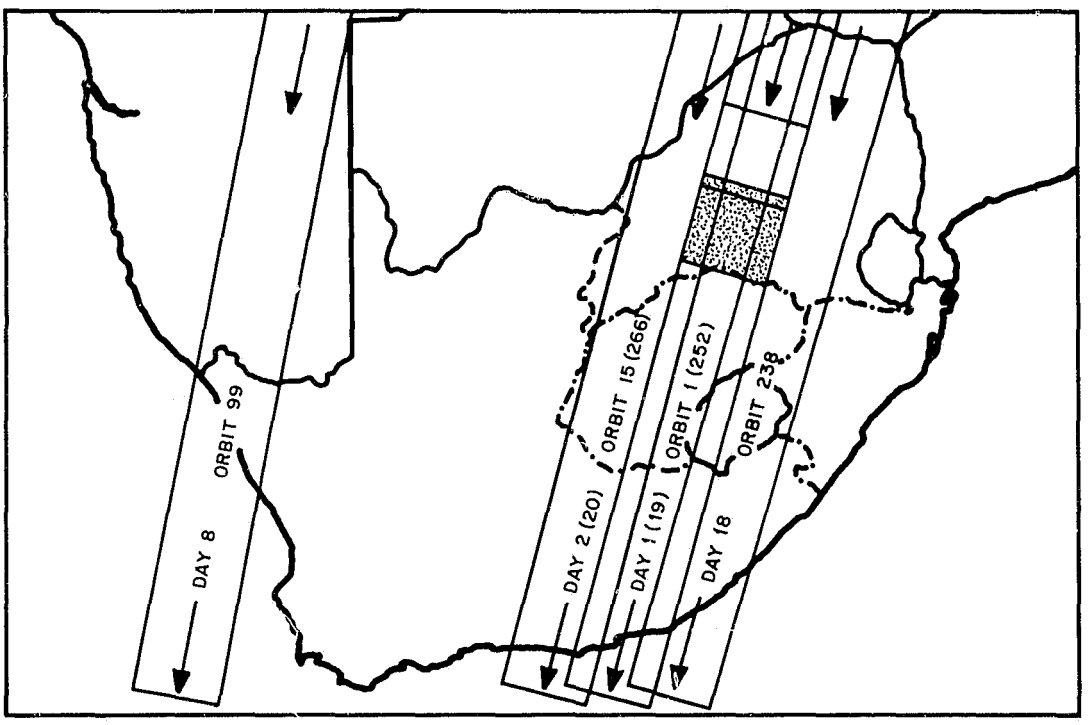


Figure 2: Landsat ground tracks over Southern Africa.

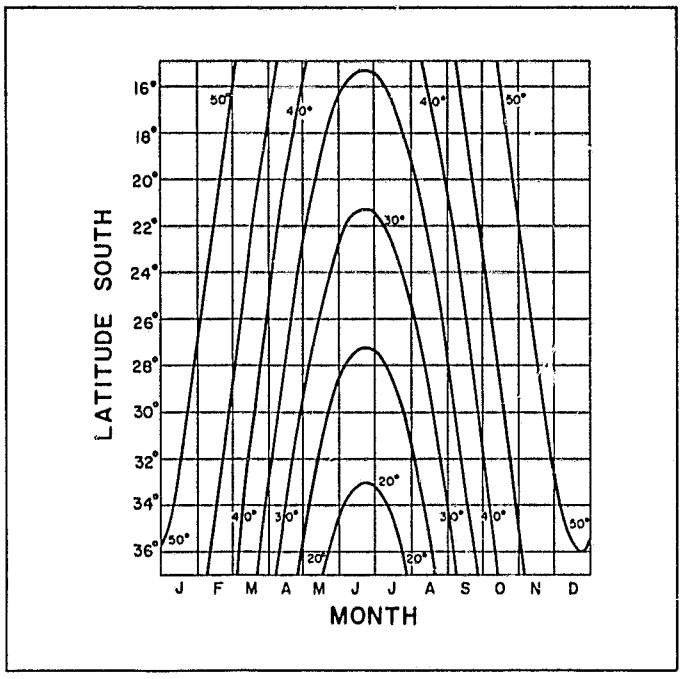


Figure 3: Solar elevation of Landsat overpass as a function of latitude and month.

motion of the spacecraft to combine with the movement of the mirror, producing a continuously repeated 'strip' of information 185 km wide. These strips are processed into images representing areas covering 185 km × 185 km on the earth's surface.

Spectral Bands

The detectors on the Landsat MSS system permit simultaneous acquisition of radiation in four spectral bands in the visible and near infra-red region of the spectrum, namely:

Band 4: 0,5 – 0,6 micrometres (green)
Band 5: 0,6 – 0,7 micrometres (red)
Band 6: 0,7 – 0,8 micrometres (near infra-red)
Band 7: 0,8 – 1,1 micrometres (near infra-red)

The data from each of these bands may be processed to obtain black and white single band images as shown in Figure 4. The different reflectance characteristics (or spectral signatures) of features on the earth's surface will determine how well they show up in any one of the four bands and differences or similarities can consequently be interpreted so that the user can study and map features of particular interest to him.

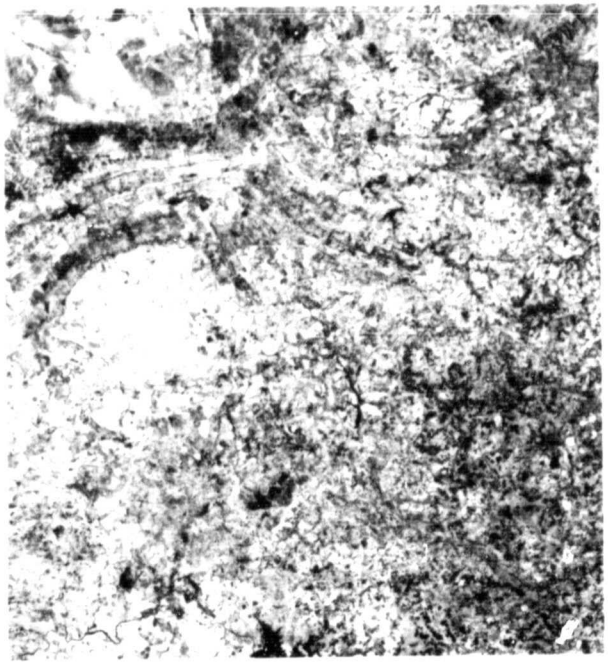
As an added feature, three of the four bands may be combined to produce a colour composite. The example shown on the cover page was produced from bands 4, 5 and 7, and the scale of the image is 1:1 000 000. On such a false colour composite, healthy vegetation will appear red (rather than green), clear water appears black, sediment-laden water is powder blue and urban centres usually appear blue or blue-grey. The example shown on the rear cover is a colour composite of part of a Landsat image showing the Saldanha Bay area on the west coast of South Africa at a scale of 1:250 000.

For general inspection, when ordering a single black and white image, it is usually best to select a black and white image of band 5. A user interested in detecting a specific feature such as veld fires will select the most useful band for his particular purpose, which in this case will be band 7.

Landsat also carries other sensors, notably a Return Beam Videcon camera system and facilities for data transmission. However, since the Satellite Remote Sensing Centre is not equipped to receive and process RBV imagery a description of this system is not given here.

Band 4 (0,5 – 0,6 micrometres)

Band 5 (0,6 – 0,7 micrometres)



Band 6 (0,7 - 0,8 micrometres)

Band 7 (0,8 – 1,1 micrometres)

Figure 4: The four individual bands, each reproduced in black and white. The scene is the same as that on the front cover. Note how differences in reflectance characteristics enable the interpreter to distinguish more easily between surface features, depending on the choice of spectral bands. The boundary between water and land is most easily determined on the image of band 7.

Spatial Resolution

In a scanner system such as the Landsat MSS, resolution is derived from the instantaneous field of view from which reflectance/radiation is being recorded, and can be expressed as a ground area. Such a picture element ('pixel') is approximately 80 m × 80 m for Landsat MSS imagery. Whilst this imposes a limitation on the capability for 'seeing' small features, it has distinct advantages for users working on a regional scale.

Digital Data

Because Landsat data are available in digital form it can be processed by computer. For example, digital processing may be used to select features of interest to the user by employing special classification or enhancement techniques. Figure 5 is an example of such a processed image, illustrating how computer classification techniques can be employed by users as an aid in the mapping of land-cover classes, which are distinguished through their distinctive spectral signatures. Products of this nature require verification by means of surface reference data and other auxiliary information before reliable maps can be produced. Users who have suitable equipment for digital image processing may prefer to order their imagery in the form of Computer Compatible Tapes (CCTs), allowing them to process the data in accordance with the needs of their specific applications.

Range of Applications

Many features contribute to the usefulness of Landsat imagery. An individual scene covers a vast area of approximately 34 000 square kilometres, providing a unique synoptic view of a surface area that could otherwise require hundreds of aerial photographs. To this should be added the capability of repetitive coverage (every 18 days) with the advantages of the sun synchronous orbit for applications such as change detection. Furthermore, the multispectral imagery and digital format can be used as such, or combined with 'conventionally' obtained information. With these advantages, Landsat imagery is a powerful aid in cartography, geology, agriculture, forestry, hydrology and other resource oriented investigations.

UNIQUE IDENTIFICATION OF LANDSAT IMAGERY

WRS Index System

The Landsat Worldwide Reference System (WRS) is a global indexing system used to retrieve Landsat data. It is keyed to the nominal scene centres and enables users to identify easily all imagery available in the vicinity of a given centre. The nominal scene centres are defined by path and row lines. The path lines are the orbital paths of the satellite, of which there are 251 every 18 days. Each path is repetitive and is considered the vertical centre line of all scenes framed over that portion of the path. On the Landsat index map for Southern Africa, as provided in this brochure, the approximate coverage of a typical MSS scene (or frame) is shown at position path (182) row (78). This coverage area is typical of a Landsat scene; in this case it is defined *geographically* by the number WRS 182–78. This is the frame reproduced on the front cover.

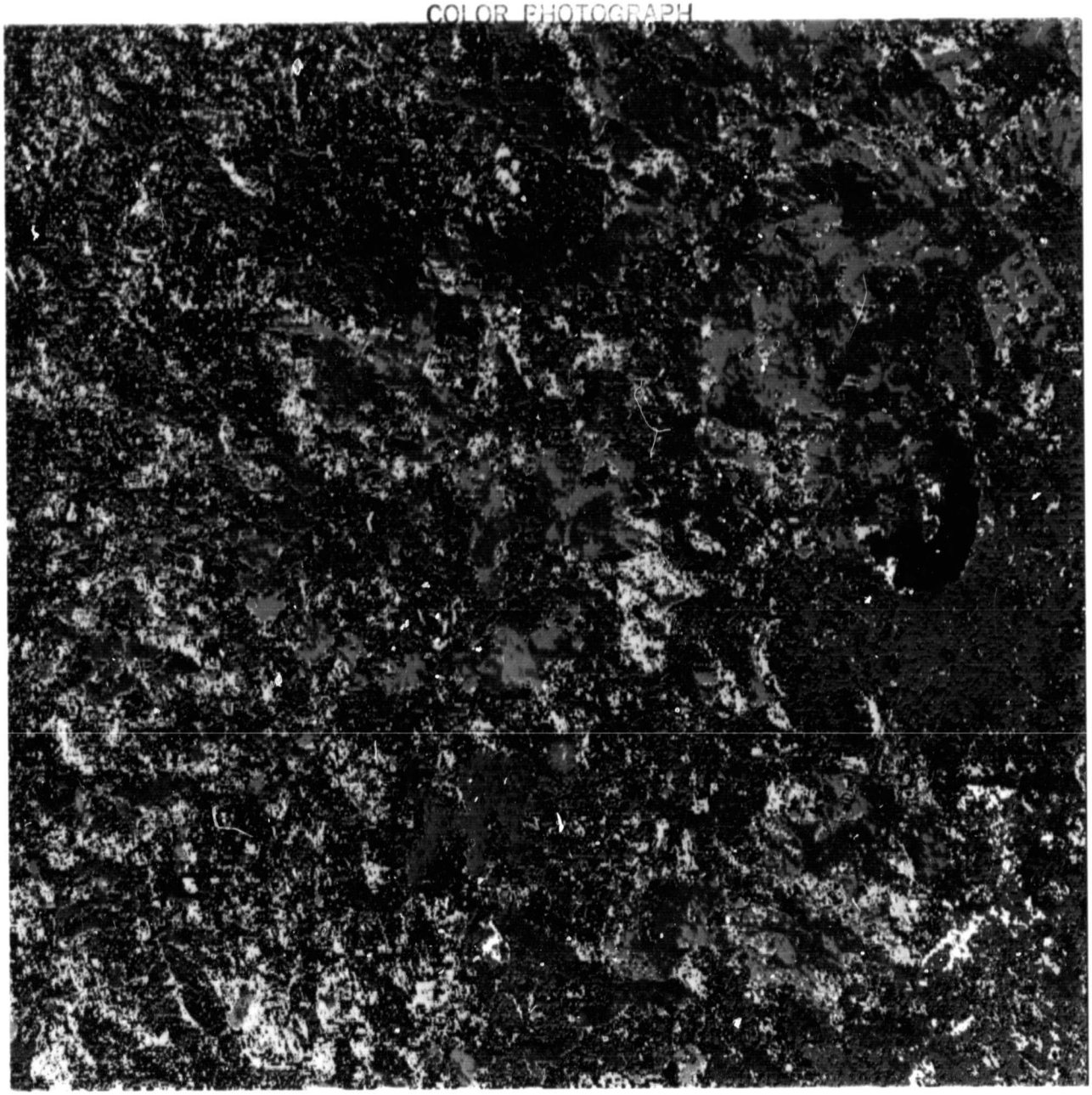


Figure 5: Result of computer classification of a Landsat scene of the Natal Midlands area. The two large dams are Albert Falls (on the right) and Midmar Dam. Pietermaritzburg is in the lower right hand corner. The classification indicates twelve land cover classes as determined by computer processing and will require verification with the aid of surface reference data and other supporting information. The land cover classes as determined by computer processing are:

Colour		Class
Light blue	—	Water (shallower or more silty)
Dark blue	—	Water (deep clear)
Bright red	—	Pine trees
Pink	—	Gum trees
Dark red	—	Indigenous bush
Brown	—	Thorn veld

Colour		Class
Green	—	Grass veld
Yellow	—	North slopes
Magenta	—	Agriculture (irrigated crops etc)
Turquoise	—	Sugar cane
White	—	Urban areas and bare sand
Grey	—	South slopes

Unique Identification Number

For any given Landsat scene such as the example WRS 182–78 mentioned above, several Landsat images (pictures) may have been acquired and stored over the years. In order to identify every image unambiguously from a temporal as well as geographical point of view, it is given a unique identification number, which must be mentioned in all orders to avoid confusion. The identification number of the image reproduced on the front cover is 22457–07143.

IMAGE ACQUISITION BY SRSC

The Satellite Remote Sensing Centre (SRSC) is operated by the National Institute for Telecommunications Research of the Council for Scientific and Industrial Research. The SRSC has undertaken responsibility for acquiring, storing and processing of a reasonable number of Landsat images of all land masses within receiving range. It is located at 25° 53 minutes south, 27° 42 minutes east. Under normal conditions it is capable of receiving Landsat images over Southern Africa south of 4° southern latitude.

Data acquired in this way by the SRSC are stored on high density digital tape or processed into a variety of formats to satisfy users' needs. At the time of writing (December 1981) SRSC policy is to acquire all available Landsat-2 MSS data for Southern Africa. Users should note that the acquisition of such data is subject to spacecraft conditions and other technical factors under the control of the US agency responsible for its operation.

Users who wish to arrange for the acquisition of Landsat MSS data on specific dates (for example to coincide with underflights or surface truth data collection) should make prior arrangements by contacting the SRSC well in advance.

LANDSAT IMAGE PRODUCTS

Imagery can be obtained from the SRSC in a variety of formats, as indicated below. Prices should be obtained from SRSC (see Product Prices, page 10).

Standard Black and White Imagery

The following corrections are applied to standard Landsat images produced by the SRSC:

- Earth rotation
- Non-uniform mirror velocity
- Panoramic distortion
- Earth's curvature distortion
- Aspect ratio

Nominal image size	*Material*	*Nominal scale*
18,5 cm	Film negative	1:1 000 000
18,5 cm	Film positive	1:1 000 000
18,5 cm	Paper	1:1 000 000
37,0 cm	Paper	1:500 000
74,0 cm	Paper	1:250 000

Standard False Colour Composite Imagery

Nominal image size	*Material*	*Nominal scale*
18,5 cm	Film positive	1:1 000 000
18,5 cm	*Paper	1:1 000 000
37,0 cm	Paper	1:500 000
74,0 cm	Paper	1:250 000

*Equal in size and scale to the illustration on the front cover.

Computer Compatible Tapes

9-Track, 1600 bits per inch (see also 'Format Description for Computer Compatible Tapes, page 10).

Standard Enhanced Imagery

Processed high quality Landsat black and white or colour composite imagery can be provided in limited quantities. Enhancement includes haze removal, de-striping, edge enhancement and correction of systematic errors, all following standard procedures. Longitude and latitude or UTM grids can also be provided. The additional cost involved for such processing should be checked with SRSC before ordering (see also 'Product Prices', page 10).

Precision geometric correction using ground control points is possible on Landsat imagery within the Republic of South Africa where 1:50 000 survey maps are available. Under favourable conditions geographic accuracies of the order of one 80 m by 80 m picture element can be obtained. Similar precision geometric corrections can also be done on Landsat imagery outside the Republic of South Africa if the user can provide 1:50 000 maps of the particular area. The additional cost for precision correction is significant and should be considered before ordering.

INFORMATION AVAILABLE TO USERS

Landsat Index Map

A Landsat index map for Southern Africa is included in this brochure. This map enables users to identify the WRS numbers of Landsat scenes covering their area of interest. Additional copies of this index map are available from the SRSC on request free of charge.

Catalogue of Available Imagery

The SRSC intends to publish, at yearly intervals, a catalogue listing MSS imagery which it has acquired and stored. The catalogue will provide information according to WRS numbers and will give scene ID number, band quality rating, cloud cover (per image quadrant), date, and latitude/longitude of the image centre. The full catalogue may be purchased by ordering from SRSC. Users may, alternatively, request extracts covering only their area of interest, which will be provided free of charge. Users may also contact the SRSC by telephone, telex or letter to obtain updated information on imagery available on their area of interest, which will likewise be provided free of charge. Enquiries must specify the area of interest by stating longitude/latitude, or the appropriate WRS reference number.

Schedule of Overpass Dates

For certain applications it may be essential for users to acquire Landsat imagery over their test areas for time periods that can be coordinated with surface observations and other data. In order to plan such operations, users are advised to obtain a schedule of Landsat overpass dates for their test area from the SRSC. Users may then make arrangements with the SRSC, who will, in turn, approach NASA to schedule data acquisition by SRSC over such areas on the selected dates. Users who make use of this procedure are not under obligation to purchase data or other imagery so acquired; they will, however, be charged the normal rates for any data they do decide to order.

Format Description for Computer Compatible Tapes

Users who have facilities for digital image processing may prefer to order their imagery in Computer Compatible Tape (CCT) format. A technical description of this format is available on request from the SRSC free of charge.

Product Prices

A price list for the range of standard image products and Computer Compatible Tapes obtainable from the SRSC is available free of charge.

CUSTOM PRODUCTS AND RESEARCH

Custom Products

The SRSC can process imagery to meet the particular requirements of specific remote sensing experimental projects. Such non-standard processing is subject to the operational workload of the SRSC and negotiation with the CSIR.

Research

The CSIR has established a National Programme for Remote Sensing to encourage research and applications in this field in South Africa, with special emphasis on the use of Landsat imagery. Users interested in proposing projects as part of this National Programme should consult the Coordinator for Remote Sensing, Cooperative Scientific Programmes, CSIR, P O Box 395, Pretoria 0001.

ORDERING IMAGE PRODUCTS

Users should specify the nature and format of imagery required and address their orders to –

The Manager
Satellite Remote Sensing Centre
c/o NITR
P O Box 3718
2000 Johannesburg
South Africa

Telephone: (012) 26-5271
Telex: 32105

Users in the Republic of South Africa can pay by cheque or postal order. Users outside the RSA must provide a bank draft in favour of the Council for Scientific and Industrial Research.

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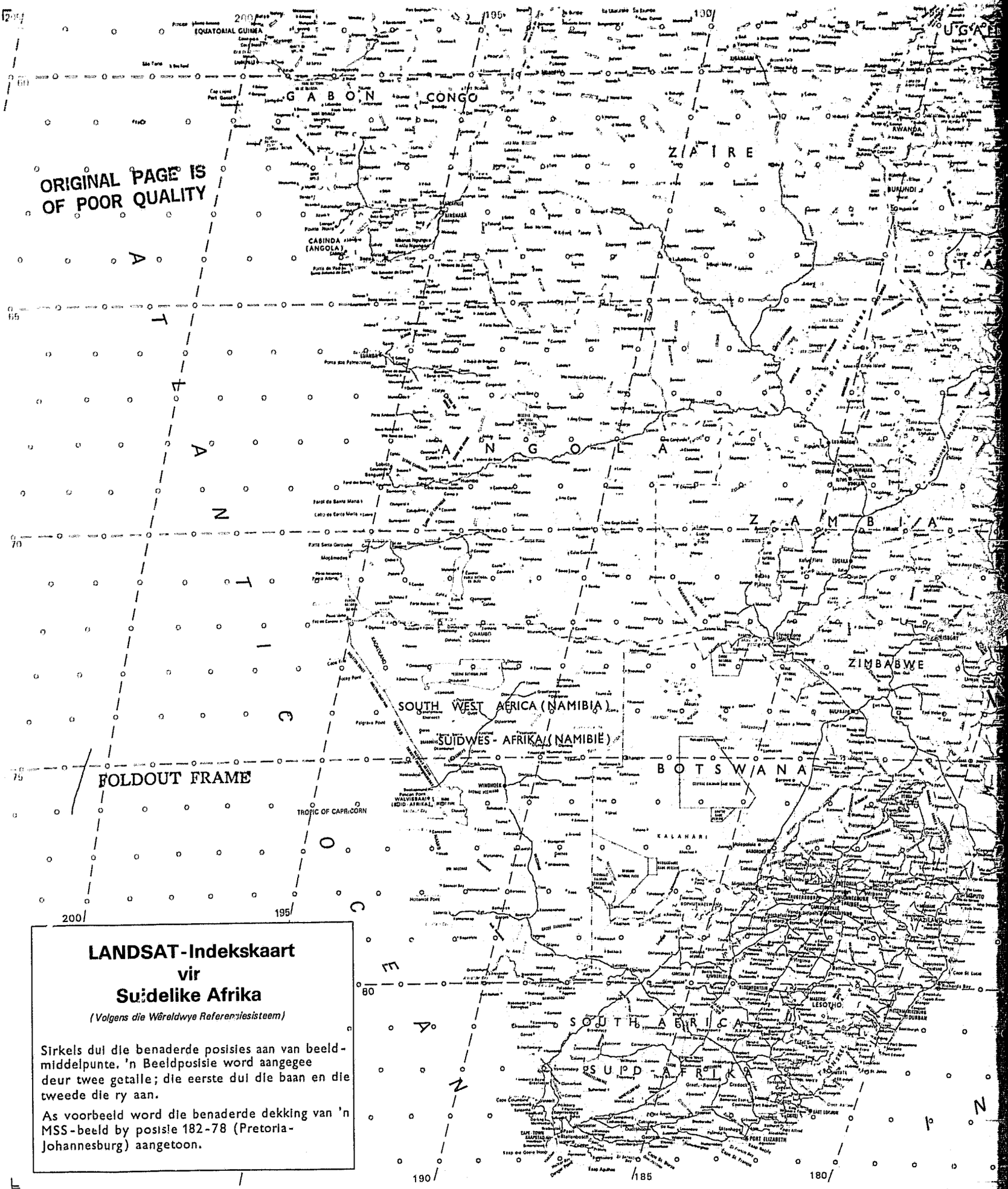
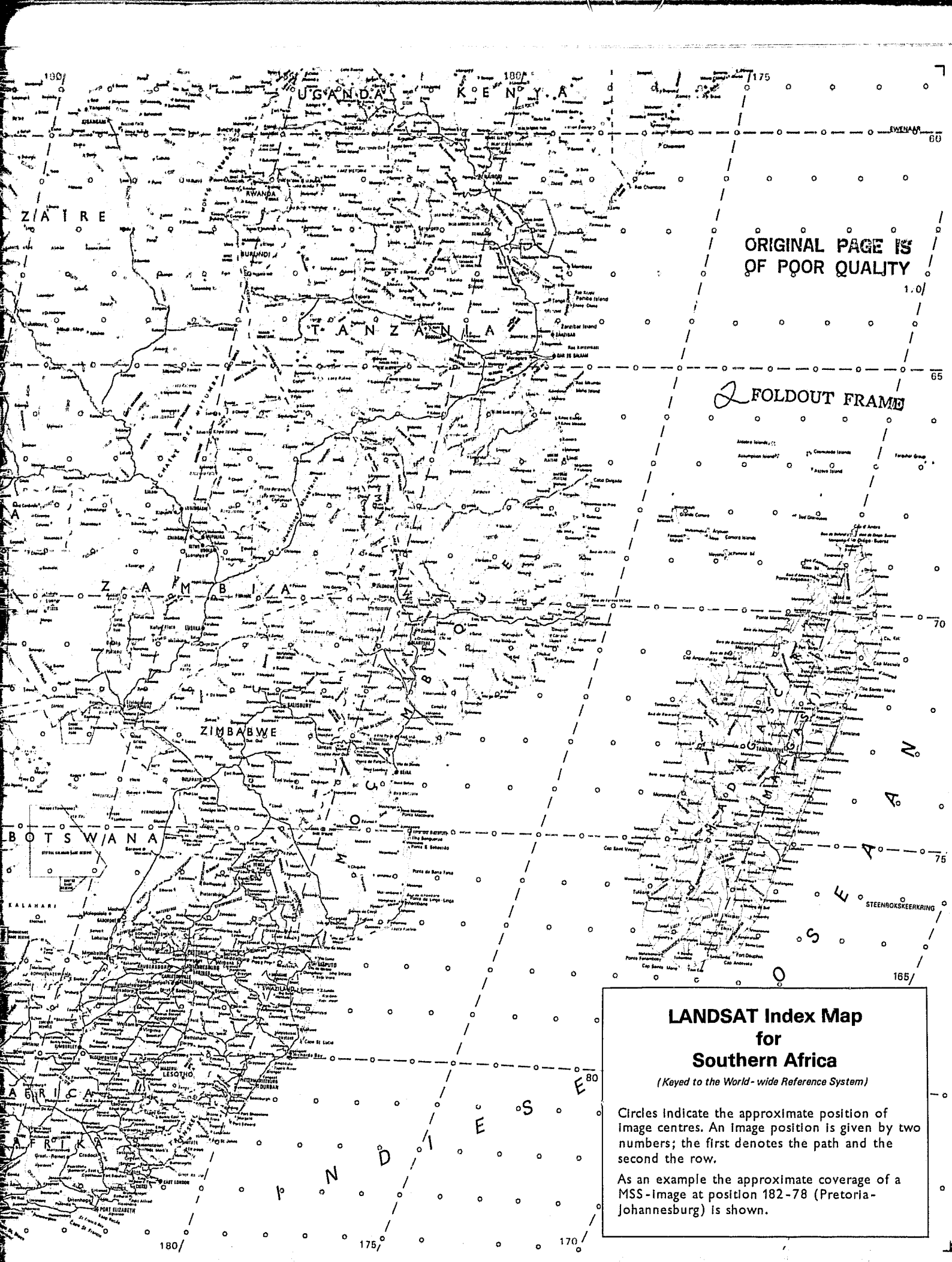


LANDSAT-Indekskaart vir Suidelike Afrika

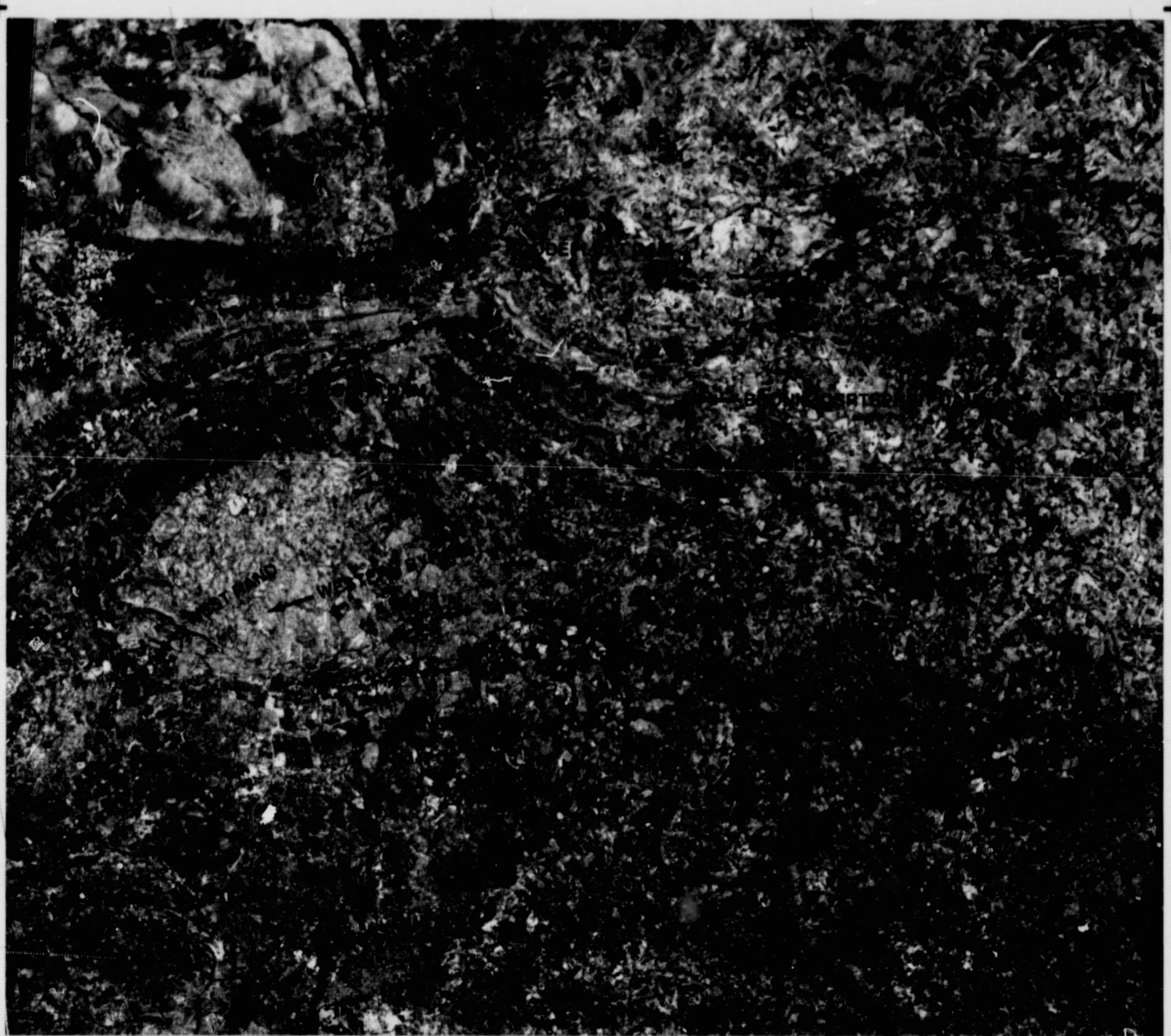
(Volgens die Wêreldwye Referensiesisteem)

Sirkels dui die benaderde posisies aan van beeld-middelpunte. 'n Beeldposisie word aangegee deur twee getalle; die eerste dui die baan en die tweede die ry aan.

As voorbeeld word die benaderde dekking van 'n MSS-beeld by posisie 182-78 (Pretoria-Johannesburg) aangetoon.


UGANDA
KENYA
ZAIRE
RWANDA
BURUNDI
TANZANIA
ZAMBIA
ZIMBABWE
BOTSWANA
LESOTHO
SWAZILAND
AFRICA
MOZAMBIQUE CHANNEL
INDIAN OCEAN
MADAGASCAR
ORIGINAL PAGE IS
OF POOR QUALITY
FOLDOUT FRAME
STEENBOKSKEERKRING
LANDSAT Index Map
for
Southern Africa
(Keyed to the World-wide Reference System)
Circles indicate the approximate position of image centres. An image position is given by two numbers; the first denotes the path and the second the row.
As an example the approximate coverage of a MSS-image at position 182-78 (Pretoria-Johannesburg) is shown.

UTM ZONE 35



Precision corrected, edge enhanced LANDSAT image. Received and processed by the SATELLITE REMOTE SENSING CENTRE of the NATIONAL INSTITUTE FOR TELECOMMUNICATIONS RESEARCH (C.S.I.R.)
Scene ID: 22457-07143 WRS: 182-78, Date:14-OCT-81 at 09h15 , Centre: S26-09 E28-29, Band: 7